
# Proceedings of the First American Conference on Human Vibration

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

National Institute for Occupational Safety and Health
NIOSH

# Proceedings of the

# First American Conference on Human Vibration

June 5-7, 2006

Waterfront Place Hotel
Morgantown, West Virginia, U.S.A.

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## Foreword

It is my pleasure to welcome the *First American Conference on Human Vibration* to Morgantown, West Virginia. This meeting showcased the most recent research regarding the physiological effects of vibration. It explored the etiology of vibration-induced disorders and illuminated opportunities for their diagnoses, treatment, and prevention.

Vibration-induced disorders, such as work-related Reynaud's disease, are serious and potentially disabling. They may result in loss of feeling and interfere with one's ability to work. NIOSH has long sought strategies to prevent vibration-induced disorders. In 1983 the Institute published a Criteria Document describing the risk of vibration syndrome from the use of hand-held machinery. Since that time the body of knowledge in this field has continued to expand. We now better understand the risk faced by workers who drive on or off road vehicles, operate marine or aircraft, or are exposed to continuous building vibration.

This conference provided us with a historic opportunity to exchange information regarding this critical occupational health issue. The agenda promised a rich and diverse scientific program as researchers and medical professionals from around the world have gathered to examine human responses to hand-transmitted vibration and whole-body vibration.

NIOSH is pleased to have hosted the first U.S. conference to examine human vibration, and I would like to thank the many scientific presenters from both the U.S. and abroad who have come to share their work with us. Together, we will advance the science further and achieve safer and healthier workplaces.

I congratulate you on a successful conference.

John Howard, MD
Director, National Institute for Occupational Safety and Health

**Acknowledgments**

The convening of the First American Conference on Human Vibration was supported by the Health Effects Laboratory Division of the National Institute for Occupational Safety and Health (NIOSH). Many thanks to Frank J. Hearl (Chief of Staff, NIOSH) for delivering the opening address. Assistance with the organization of the conference was provided by Jamie Long (West Virginia University -- Continuing Education) and Barbara Elbon, Thomas McDowell, Daniel Welcome, and Christopher Warren (NIOSH). Editing, cover design, graphics, and layout were provided by Kimberly Clough Thomas (NIOSH). Tanya Headley (NIOSH) provided assistance with the final editing.

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## Introduction

Vibrations caused by power tools, machinery, vehicles, and heavy equipment are a ubiquitous feature of modern work environments. In the U.S., an estimated six million workers are in occupations exposed to whole-body vibration and more than one million workers are in occupations exposed to hand-transmitted vibration (U.S. Bureau of Labor Statistics, 2004). Since Alice Hamilton's seminal report in 1918 on vibration-induced hand disorders in quarry stonecutters, the potential health risks associated with prolonged and repeated vibration exposure have been well recognized and documented. Efforts to understand the exposure risk factors and adverse health effects of occupational vibration exposure have waxed and waned over the years. Despite numerous studies and technological advances in vibration measurement and control, the exposure risks and etiology of the adverse health effects are not well understood. Human exposure to vibration remains a major risk factor associated with vascular, neural, and musculoskeletal disorders.

The First American Conference on Human Vibration (ACHV) was held in Morgantown, West Virginia, June 5-7, 2006. It was organized by the Health Effects Laboratory Division of the National Institute for Occupational Safety and Health and West Virginia University Department of Continuing Education. This conference provided a unique opportunity for a multidisciplinary group of national and international experts to exchange current information on all aspects of segmental and whole-body vibration exposures. The attendees included industrial hygienists, engineers, physicians, epidemiologists, scientists, psychologists, physiologists, health and safety specialists, consultants, students, and other individuals from Government, industry, and academic institutions from the U.S., Canada, and more than seven other countries.

Four keynote lectures and more than 60 papers were presented at this conference. Topics included vibration exposure measurement and quantification, biodynamic responses of whole-body and hand-arm system, subjective perceptions of vibration, physiological and pathological mechanisms, health effects, clinical diagnoses, epidemiological studies, prevention effectiveness, standard development and implementation. Presentations also described recent technological advances that may improve vibration measurement, tool and vehicle seat designs and tests, personal protection devices, and clinical diagnosis and assessment methods.

The ACHV was intended to prompt the convening of future, biennial conferences on human vibration in North America. We hope that the publication of these conference proceedings will help encourage new research and technological advances so that the health hazards associated with occupation vibration exposures will be significantly reduced.

Ren Dong
Kristine Krajnak
Oliver Wirth
John Wu

Morgantown, West Virginia

## Keynote Speakers

### Michael J. Griffin

Michel Griffin, BSc., Ph.D., is the head of the multi-disciplinary Human Factors Research Unit in the Institute for Sound and Vibration Research at the University of Southampton in England. Professor Griffin is the Chairman of the British Standards Institution Sub-Committee concerned with human response to mechanical vibration and shock. He is also a member of relevant committees of the International Organization for Standardization and the European Committee for Standardization. Professor Griffin has particular research interests in biodynamics, human performance, ride comfort in vehicles, vibration-induced injuries, and motion sickness.

### Setsuo Maeda and Neil J. Mansfield

Setsuo Maeda, Dr.Eng., Dr.Med.Sci. is the Director of Department of Hazard Assessment at Japan National Institute of Occupational Safety and Health in Kawasaki, Japan. His research interests include human response to multi-axis whole-body vibration and multi-axis hand-arm vibration. Neil Mansfield, B.Eng., Ph.D., is a Senior Lecturer in the Department of Human Sciences at Loughborough University in the U.K. He is Technical Director of OPERC hand-arm vibration test centre (HAVTEC) and heads the Vibration, Biomechanics and Noise research group of Loughborough University's Environmental Ergonomics Research Centre. He has worked in the area of human response to vibration and noise for 15 years as a consultant.

### Hisataka Sakakibara

Hisataka Sakakibara, M.D., Ph.D. is a Professor at Nagoya University School of Health Sciences in Nagoya, Japan. His major research focuses on the pathophysiological effects of hand-arm vibration.

### Chris Nelson

Chris Nelson, Ph.D. is a Specialist Inspector (Noise and Vibration) with the U.K.'s Health and Safety Executive (HSE). He has recently been involved with the development of British legislation, and supporting guidance, to implement the European vibration directive. He is also convener of the ISO and CEN working groups on hand-arm vibration. Prior to joining the HSE, Chris spent some years involved in research and consultancy work at the Institute of Sound and Vibration Research, Southampton University, gaining a Ph.D. for his study of vibration-induced white finger in dockyard employees. He then joined the Institute of Naval Medicine as Head of Acoustics and Vibration, moving to the HSE in 1997.

**Keynote Presentation**

# HEALTH EFFECTS OF VIBRATION – THE KNOWN AND THE UNKNOWN

Michael J. Griffin
Institute of Sound and Vibration Research, University of Southampton, U.K.

## Introduction

Science involves the study of the nature and behaviour of natural things and the knowledge we obtain about them. Scientific endeavour leads to the unfolding of new knowledge and adjustments to our understanding and our behavior. To indicate that we 'know' something may merely mean we do not feel able to, or that we do not wish to, disagree with others who claim to know; or it may mean we have either heard about it, or studied it, or understand part of it, or accept that it is true, or have seen evidence to be convinced of its veracity. What do we 'know' about the health effects of vibration?

There are many unknowns in the field of human responses to vibration. Not all would agree on what is known and what is unknown. This paper seeks to summarize what we know that we know, what it is sometimes claimed that we know, and what we know that we do not know about the relation between exposures to vibration and our health. It also speculates on what we do not know that we do not know.

## Hand-transmitted vibration

*What we know we know*

We know that exposures to hand-transmitted vibration result in various disorders of the hand, including abnormal vascular and neurological function. Not all frequencies, or magnitudes, or durations, of hand-transmitted vibration cause the same effects.

*What we may claim to know*

To enable exposures to be reported and compared, they are 'measured' and 'evaluated' using defined (e.g. standardised) procedures. This involves identifying what is to be measured and specifying how it is expressed by one (or a few) numbers. Summarising a vibration exposure in a single value involves assuming the relative importance of components within the vibration (e.g. different magnitudes, frequencies, directions, and durations), so standards define 'weightings' for these variables. The importance of the weighted values may also be suggested, allowing 'assessments' according to a criterion (e.g. the probability of a specific severity of a specific disease).

Standards for the measurement and evaluation of hand-transmitted vibration define a frequency weighting and time dependencies that allow the severity of vibration exposures to be assessed and the probability of finger blanching to be predicted [1].

*What we do not know*

We do not know that the frequency weighting in current standards reflects the relative importance of different frequencies and axes of vibration in producing any specific disorder. We do not know whether the energy-based daily time-dependency inherent in $A(8)$ reflects the relative importance of vibration magnitude and daily exposure duration. Consequently, the relation between $A(8)$ and the years of exposure to develop finger blanching, as in an appendix to ISO 5349-1 (2001), is not well-founded.

We do not know, or at least there is no consensus on, the full extent of the disorders caused by hand-transmitted vibration (e.g. vascular, neurological, muscular, articular, central), or the pathogenesis of any specific disorder caused by hand-transmitted vibration, or the roles of other factors (e.g. ergonomic factors, environmental factors, or individual factors). We know that acute

exposures to hand-transmitted vibration cause both vascular and neurological changes analogous to the changes seen in those occupationally exposed to hand-transmitted vibration, but we do not yet know how the acute changes relate to the chronic disorders.

## Whole-body vibration

*What we know we know*

We know that many persons experience back pain and that some of these are exposed to whole-body vibration. We know that in the population at large, occupational exposures to whole-body vibration are not the main cause of back problems, and that ergonomic factors (e.g. lifting and twisting) and personal factors are often involved. We know vibration and shock can impose stresses that could supplement other stresses.

*What we may claim to know*

Measurement methods and evaluation methods have been defined in which the frequencies, directions and durations are weighted so as to predict the relative severity of different vibrations and indicate the magnitudes that might be hazardous [2].

*What we do not know*

We are not able to predict the probability of any disorder from the severity of an exposure to whole-body vibration. We do not know whether there is any disorder specific to whole-body vibration, or what disorders are aggravated by exposure to whole-body vibration. We do not know the relative importance of vibration and other risk factors in the development of back disorders.

## Discussion

Providing guidance to others involves compromises – a perceived need, or other argument, may outweigh the cautious interpretation of scientific evidence. Standards for measuring and evaluating human exposures to vibration use uncertain frequency weightings and time dependencies but allow legislation for the protection of those exposed [3]. The standards may appear useful, but it is prudent to distinguish between standards and knowledge – between what is accepted to reach a consensus and what can be accepted as proven. Standards may guide actions but not understanding.

Where reducing risk solely involves reducing vibration magnitude or exposure duration, ill-founded evaluation methods will not increase risk. Where prevention involves a redistribution of vibration over frequencies or directions, or balancing a change in magnitude with a change in duration, an inappropriate evaluation method can increase risk. For example, the hand-transmitted vibration frequency weighting, which may be far from optimum, implies that gloves give little beneficial attenuation, whereas a different weighting might indicate that gloves can be a useful means of protection [4].

What do we not know that we need to know? Not all appreciate the benefits of placing more reliance on traceable data than on consensus. Traceability is fundamental to quality systems but deficient in current standardization. Standards can comfort their users – justifying actions without resort to understanding – while concealing assumptions that may prevent the minimization of the risks of injury from exposures to vibration.

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